70TH ESCVS CONGRESS & 7TH IMAD MEETING

20 I 23 JUNE 2022

CHU de Liège | LIÈGE université | ANEURYSMAL PATHOLOGY Foundation 2009

CARDIAC SYMPOSIUM 9 | HOW TO REVASCULARIZE PATIENTS WITH ISCHEMIC CARDIOMYOPATHY

The combined use of TTFM and HFUS imaging to optimize outcomes in CABG – a practical approach

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2018 ESC/EACTS Guidelines on myocardial revascularization

Minimize aortic manipulation: ***IB***

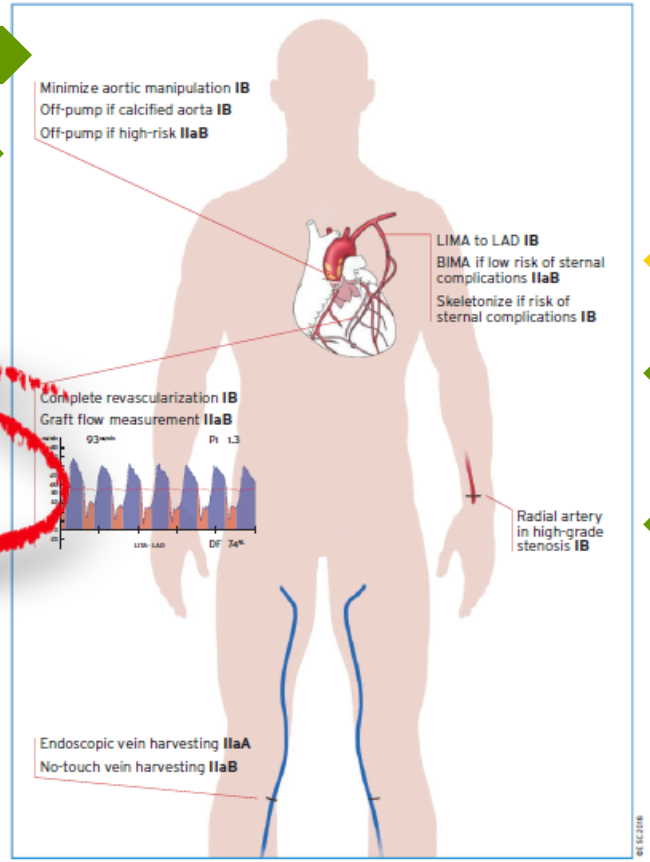
Off-pump in calcified aorta: ***IB***
Off-pump in high-risk: ***IB***

Complete Revasc: ***IB***

Graft flow measurement: ***IIaB***

Endoscopic SVG harvesting: ***IIaA***

No-touch SVG harvesting: ***IIaB***



LITA to LAD: ***IB***

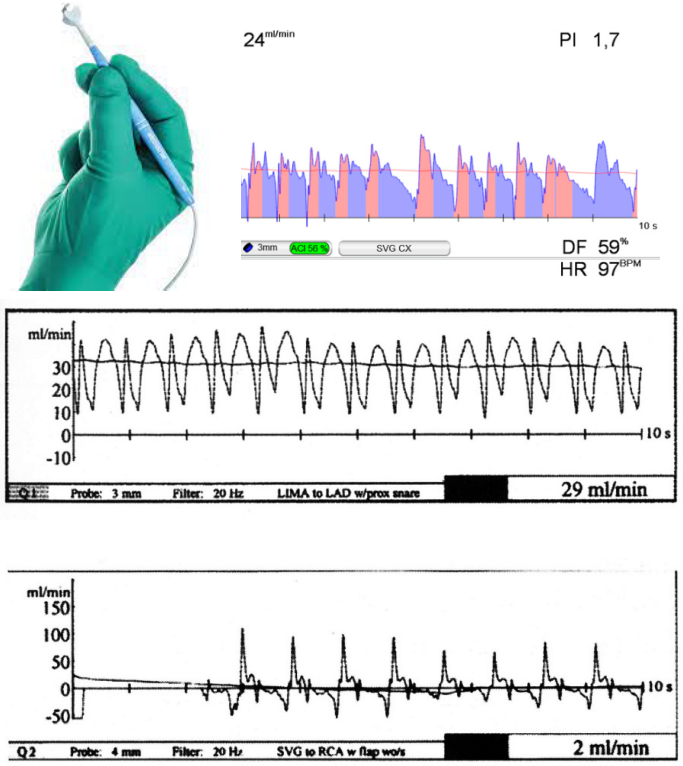
BITA if low risk for DSWI: ***IIa B***

Skeletonize if risk for DSWI: IB

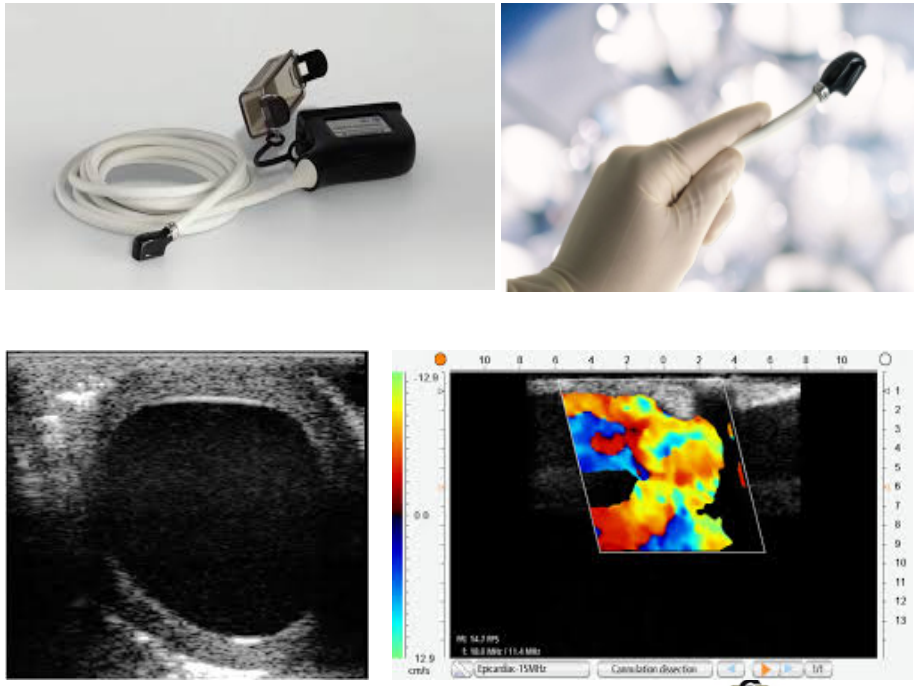
Radial artery in high-grade stenosis: ***IB***

Neumann et al. EHJ/EJCTS 2018

Transit time graft flow measurement (TTFM)

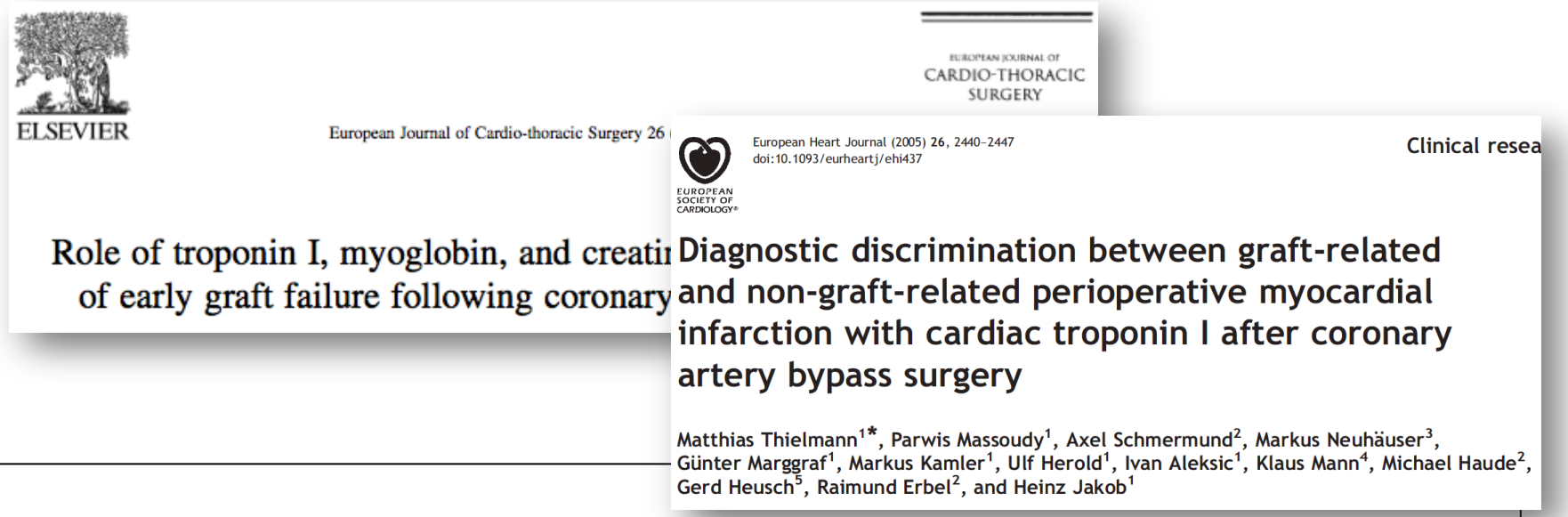


High frequency epicardial ultrasound (HFUS)



Walpoth et al. ATS 1998;66:1097-100
Beldi et al. ATS 2000;70:212-17

Intraoperative graft flow measurement (TTFM) and its relation to graft failure and PMI



2078 pts. 100% CABG

- 2.6% (55pts) PMI (cTNI, Myo, CK, ECG) → repeat angiography
- 1.6% (35/55) showed graft failure

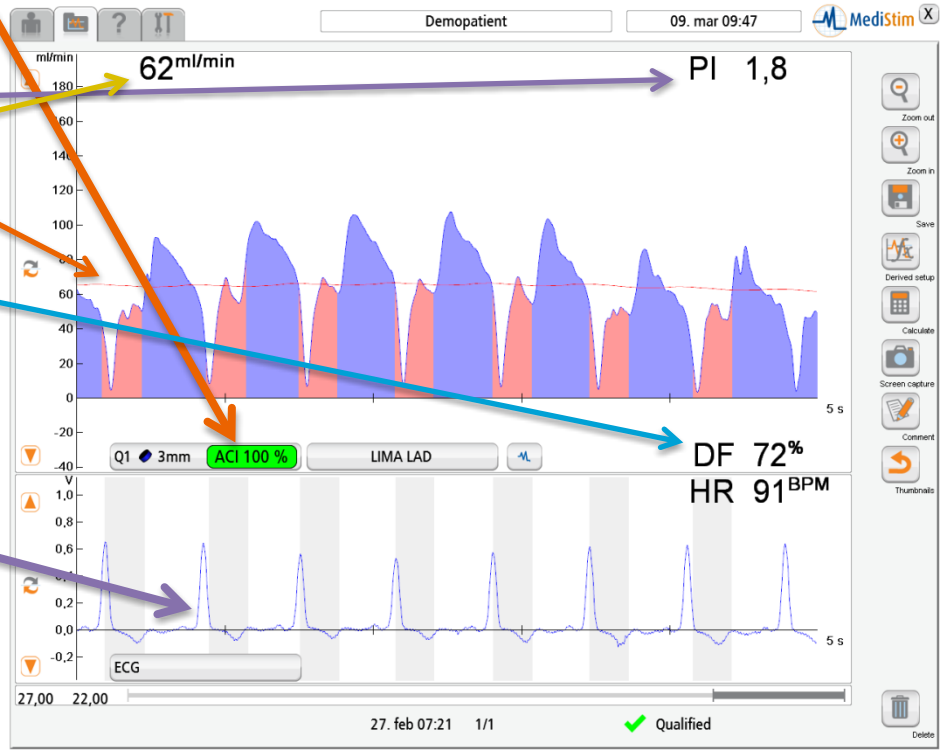
- **TTFM was implemented and routinely applied since 1999!**
- **Mean flow in graft failure pts. 30 ml/min vs. 60 ml/min** ***p=0.002***

Thielmann *et al., EJCTS 2004;26:102-9.*
Thielmann *et al., Eur Heart J 2005;26:2440-7.*

…a practical approach!

What do the numbers mean?

1. Mean Arterial Pressure (MAP)
2. Acoustic Coupling Index (ACI)
3. Steady red line
4. PI
5. % DF
6. Flow
7. Shape of curve
8. ECG to match systolic and diastolic phases



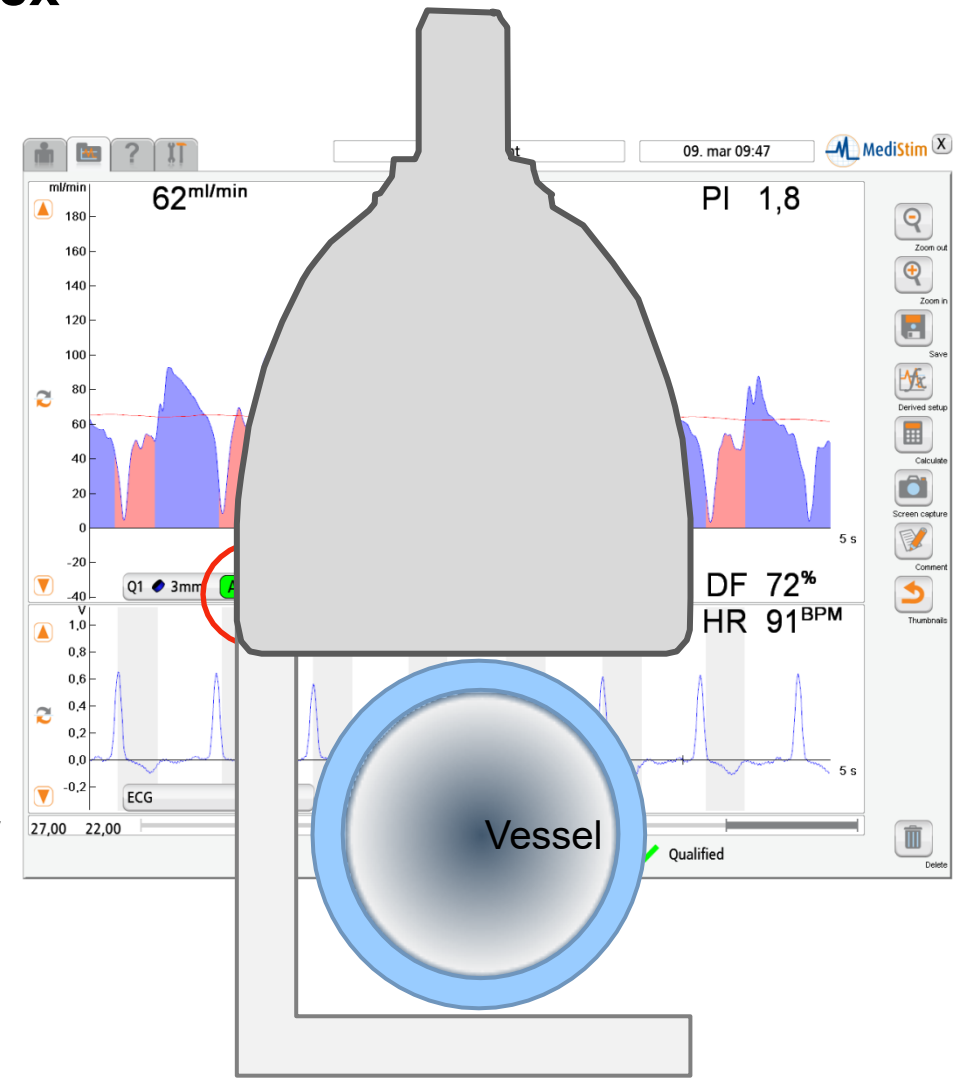
Consider adequate mean arterial pressure!

- Available on the surveillance monitor in the OR
- Should be ~ 80 mmHg
- Results and values (PI < 5 & DF > 50%) were validated using BP ~ 80 mmHg
- Affects the Flow, the PI, the flow curve and %DF

ACI – Acoustic coupling index

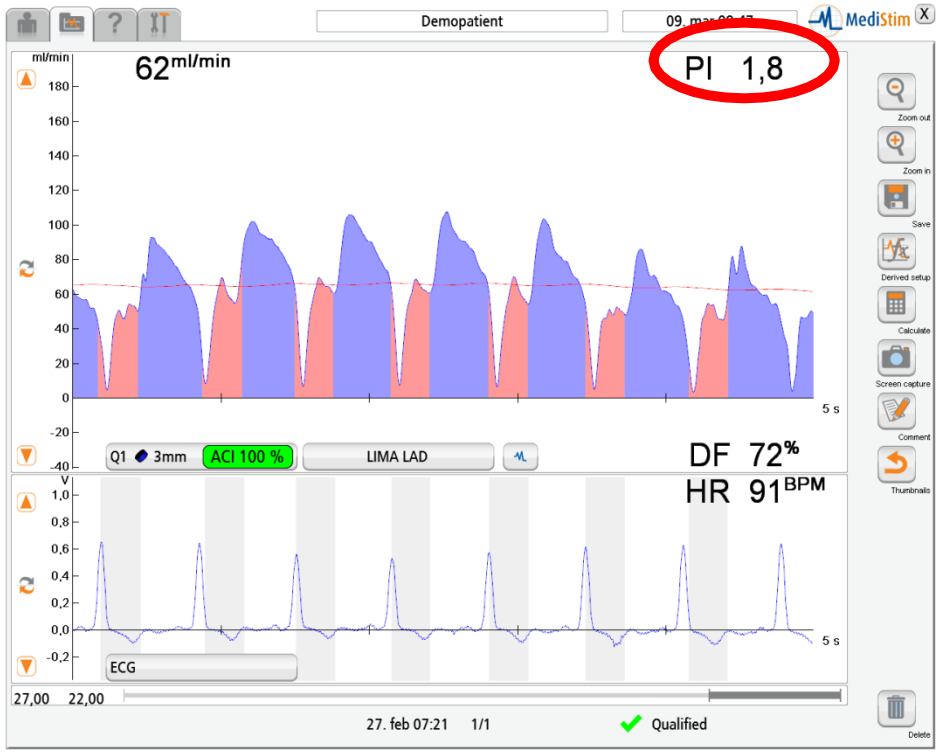
- Indicates how good the connection is between the probe and the vessel/graft
- Green – Excellent > 50%
- Yellow – OK > 31%
- Orange – not OK < 30%
- Red – Bad connection

- The connection can sometimes improve by using aquaous gel (ultrasound gel), or other liquids available.



PI – Pulsatility Index

- Definition:
  - Pulsatility Index $= \frac{Q_{Max} - Q_{Min}}{Q_{Mean}}$
- The PI is a measure of the variance of blood flow throughout the cardiac cycle
- In most cases PI < 5 is OK (guidelines)
- Other studies even refer to a PI < 3
- High PI indicates there's something obstructing the flow
  - Stenosis
  - Stiching
  - Flap
  - ++++???



DF – diastolic filling

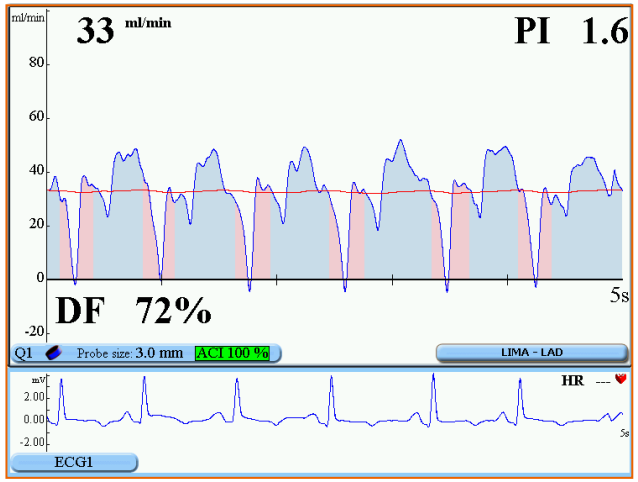
- Available only when ECG is connected
- Percentage of the total filling that's in the diastolic phase
- Normal with different expected values for right and left ventricle
  - Left ventricle ~ 70%
  - Right ventricle ~ 50%

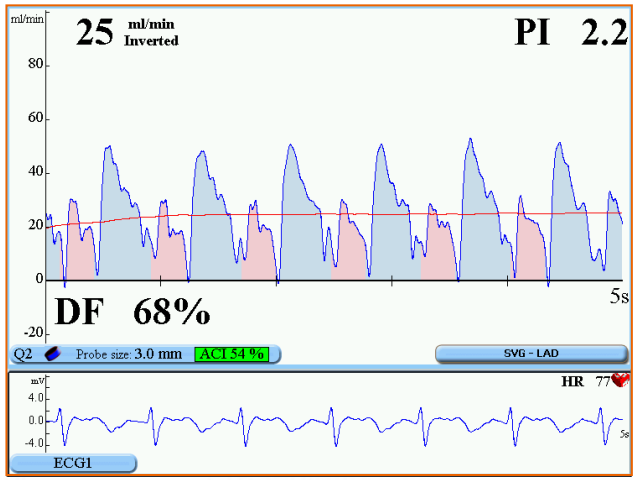
- The systolic and diastolic phases are separated with colors.
- Blue area represents the diastolic filling

Flow

- The value of the flow varies with graft, native vessel, patient ++
- ASK the surgeon what she/he expect the value to be!
- Occlude or snare the native vessel to check the values for competetive flow and other possible surprices
- TTFM should be repeated before chest closure and after protamine administration to confirm graft patency and to detect possible graft kinking or compression.

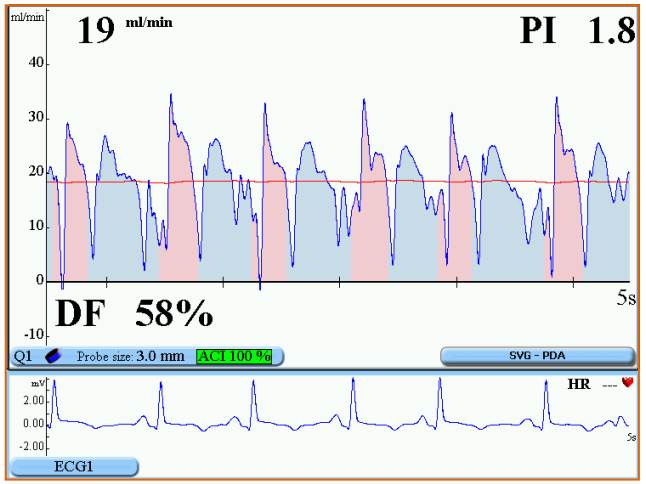
Normal Wave Patterns

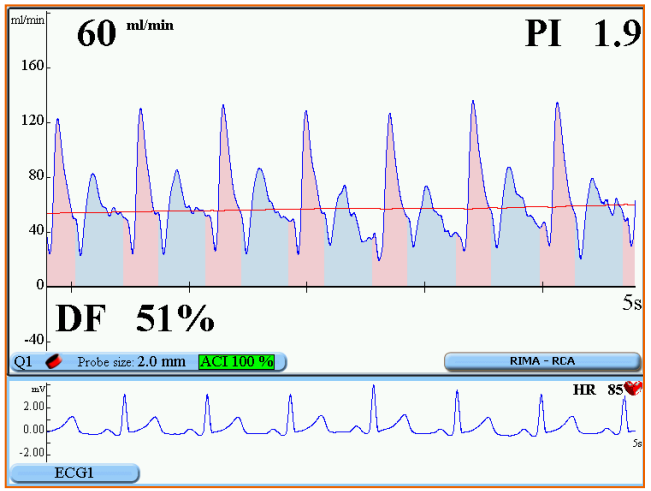




- Arterial grafts
  - IMA and RA
  - “Soft M” shape
  - More likely to spasm
- Vein grafts
  - SVG – Saphenous Vein Graft
  - Dual-beat-shape on curve
- Left side coronaries
  - Diastolic dominant
  - Expect %DF ~70%

Normal Wave Patterns

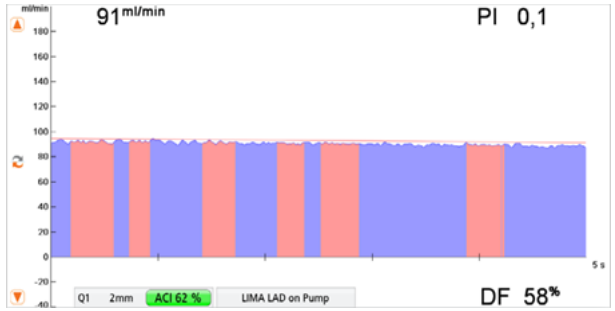




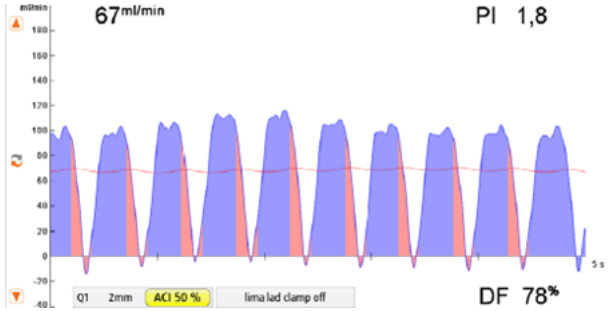
- Right side coronaries
  - Higher contribution of systolic flow
  - Expect %DF to be ~50%

TTFM at different timepoints

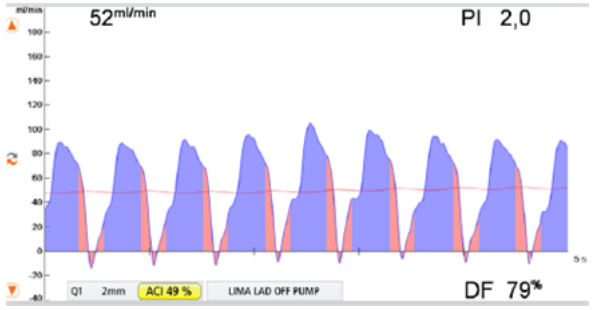
1 ON PUMP CLAMP ON



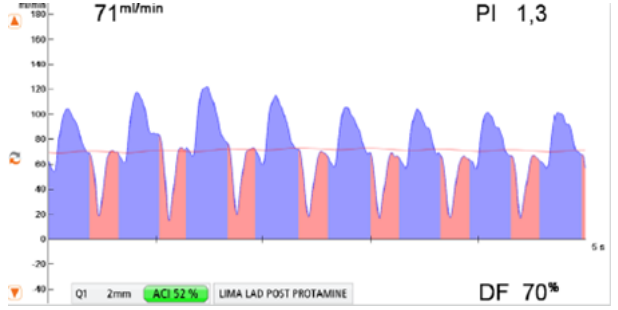
2 ON PUMP CLAMP OFF



3 PRE PROTAMINE

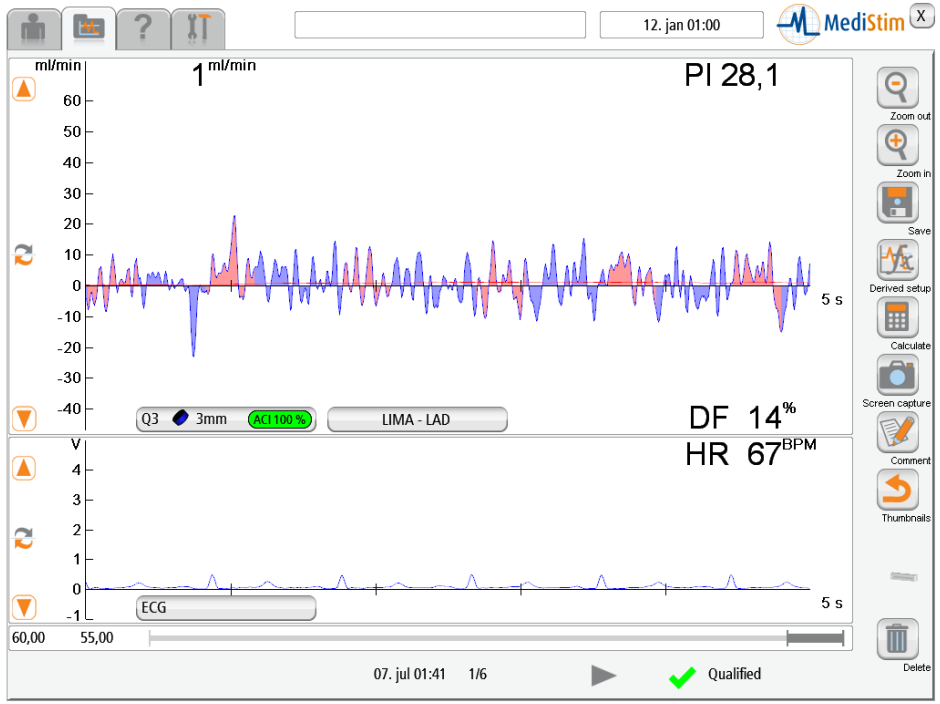


4 POST PROTAMINE BEFORE CHEST CLOSURE



Is it a bad graft?

- Is the graft proximal to the stenosis?
- Competitive flow or steal syndrome?
- Spasms in an arterial graft or the coronary bed?
- Kinked graft
- Twisted graft
- Bad anastomosis, bad stiching, flap
- Occluded graft or another stenosis distal to anastomosis
- Dissection of graft
- Dissection of native artery

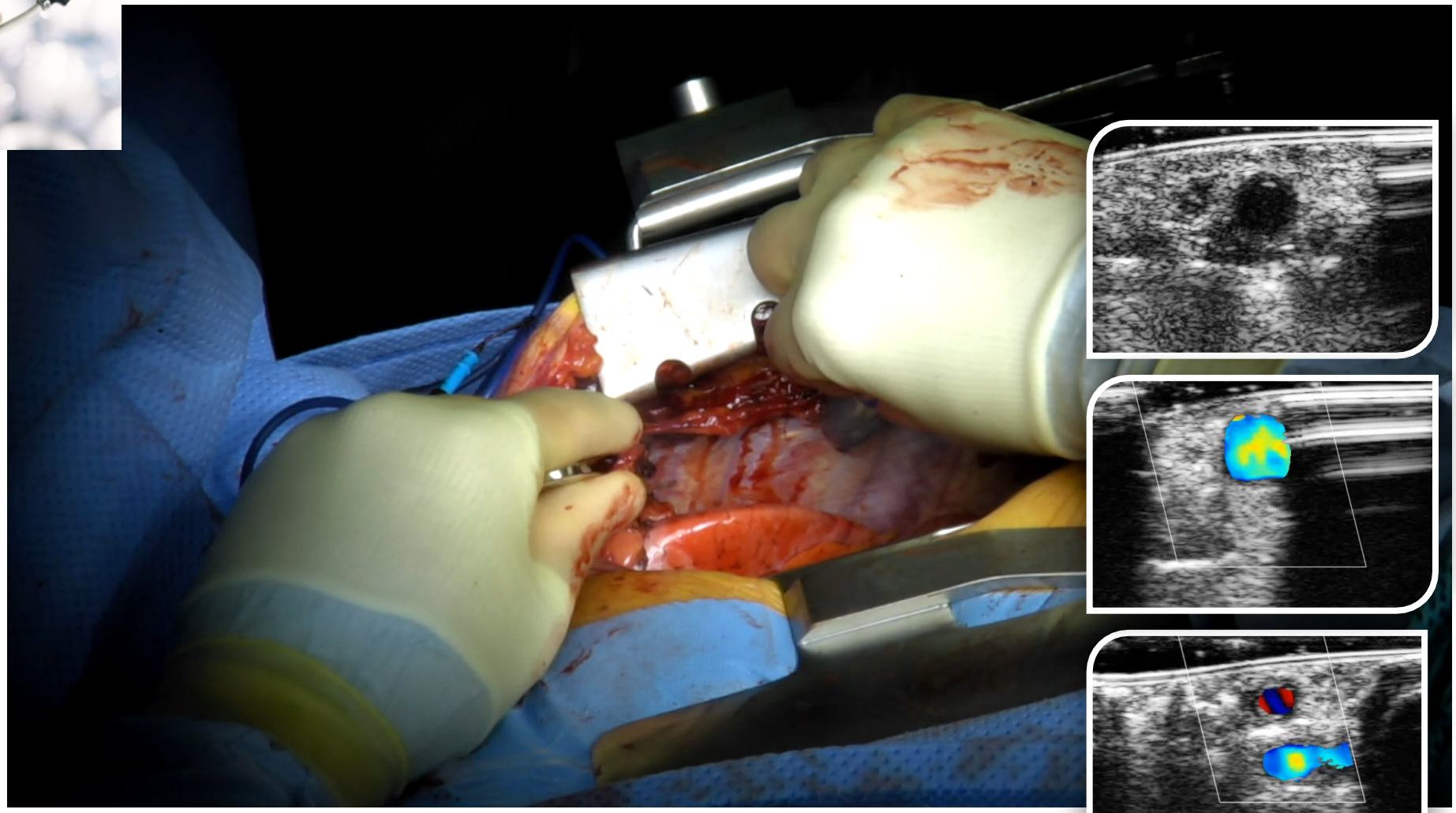


What to do?

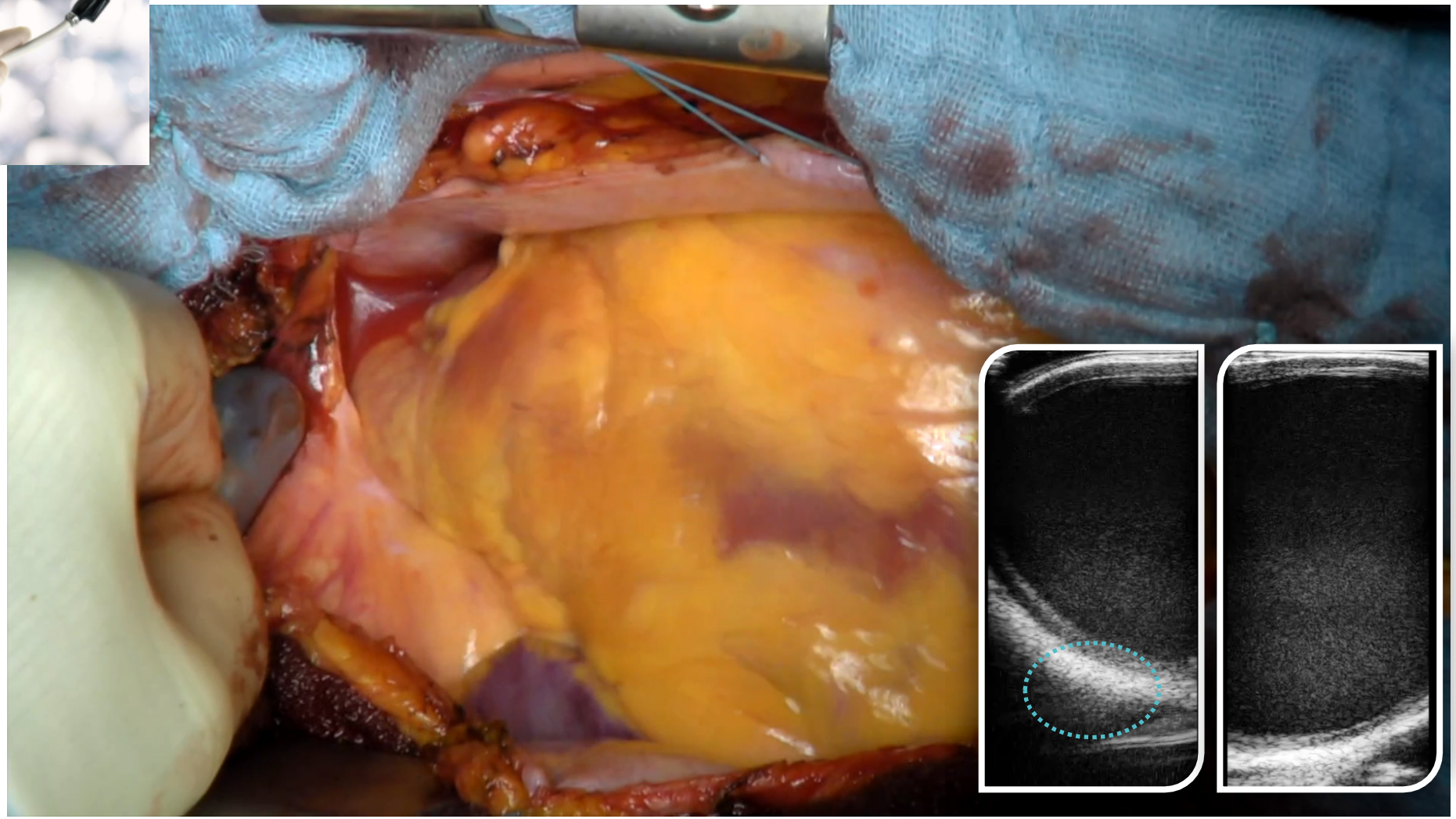
- ✓Due to competitive flow? Backward flow?
- ✓Diffuse disease of coronary arteries?
- ✓Poor graft (proximal / distal anastomosis)
- ✓Visible problems?
- ✓Remeasure
- ✓Perform snare test to native vessel, prox to anastomosis
- ✓Knowledge of the vessel grafted
- ✓Use imaging to check anastomosis

➢**If neither of the above – consider a revision!**

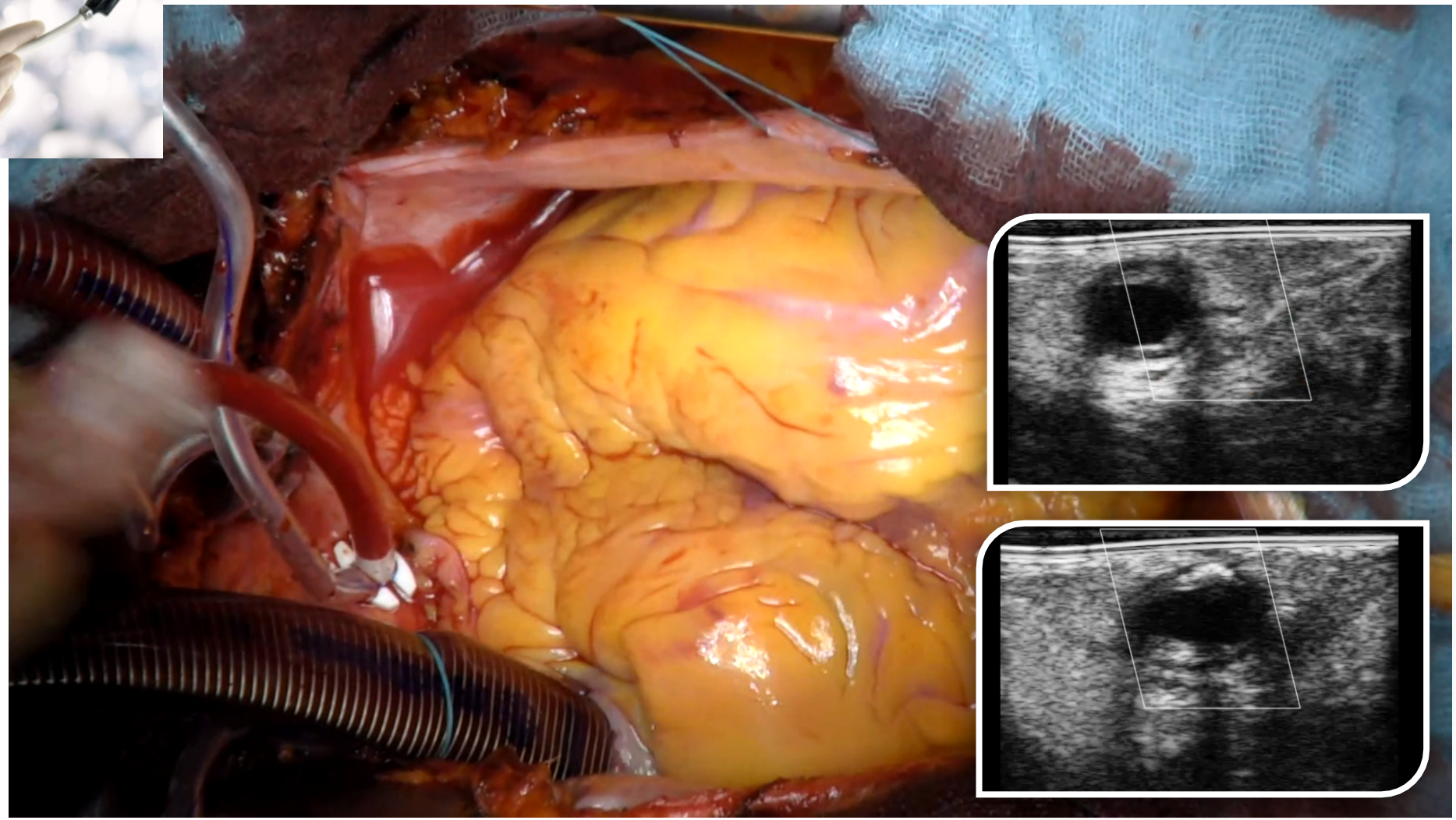
LITA in-situ scanning



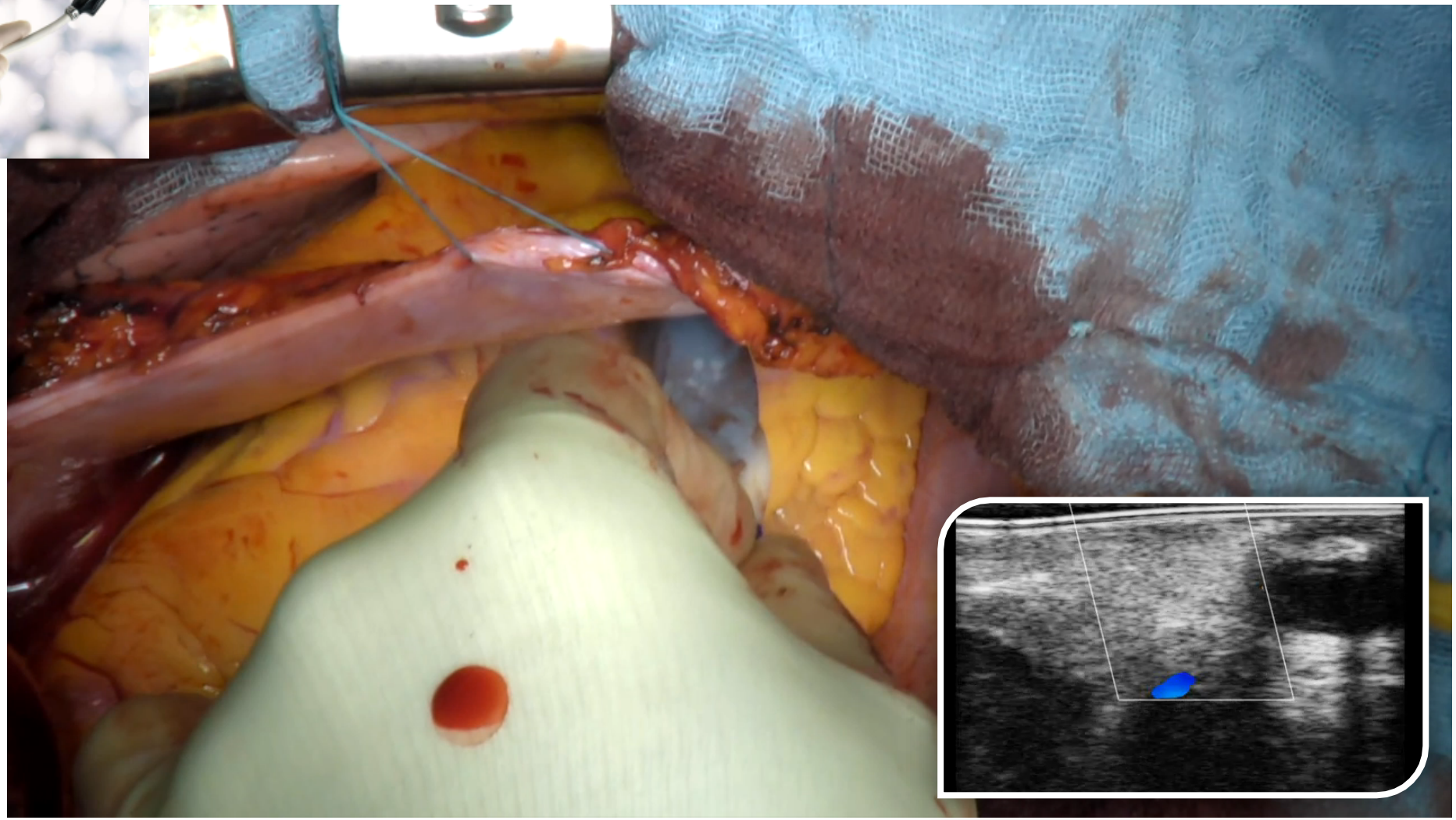
Aorta scanning



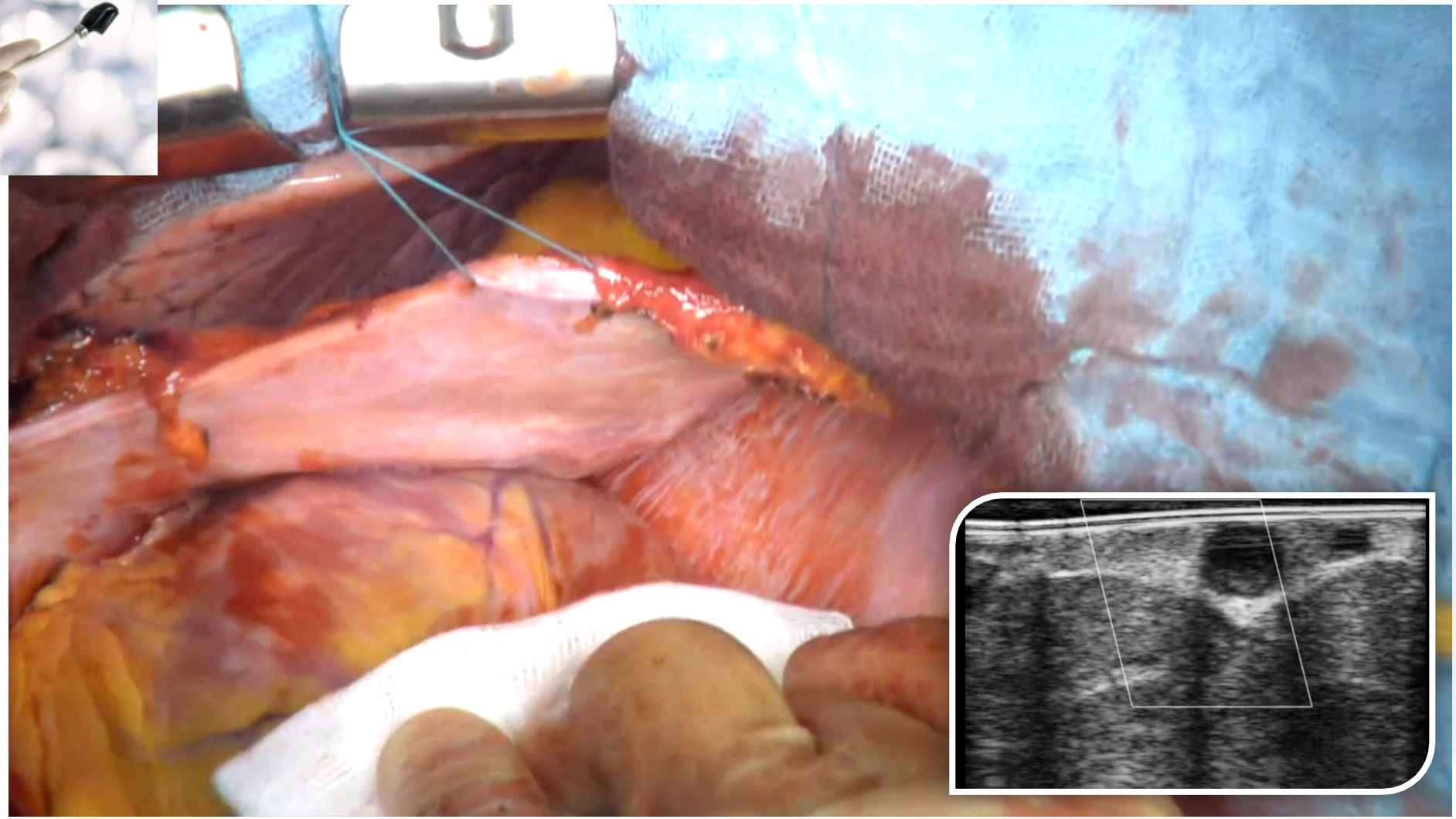
Target coronary scanning: RCA



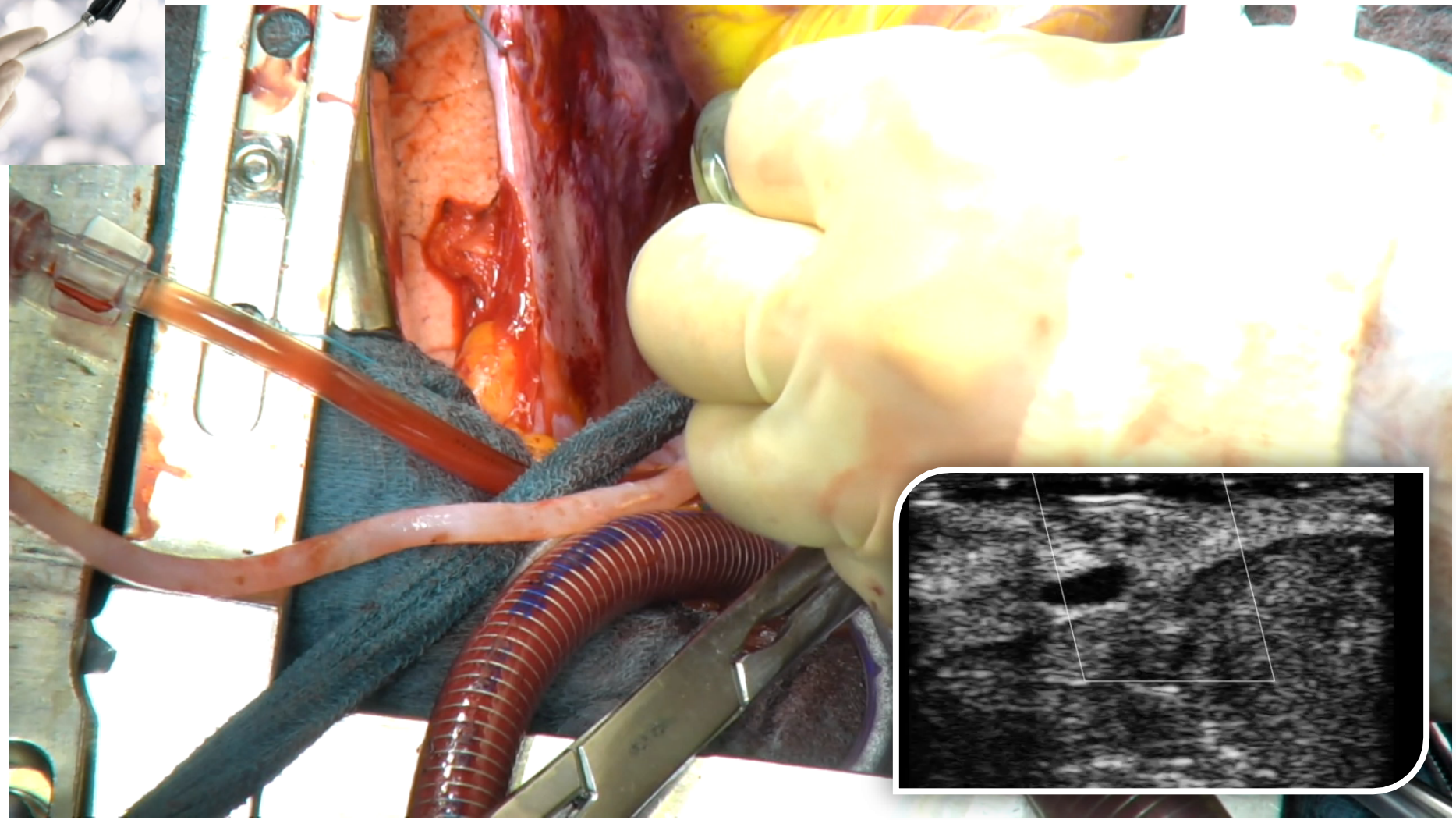
Target coronary scanning: LAD



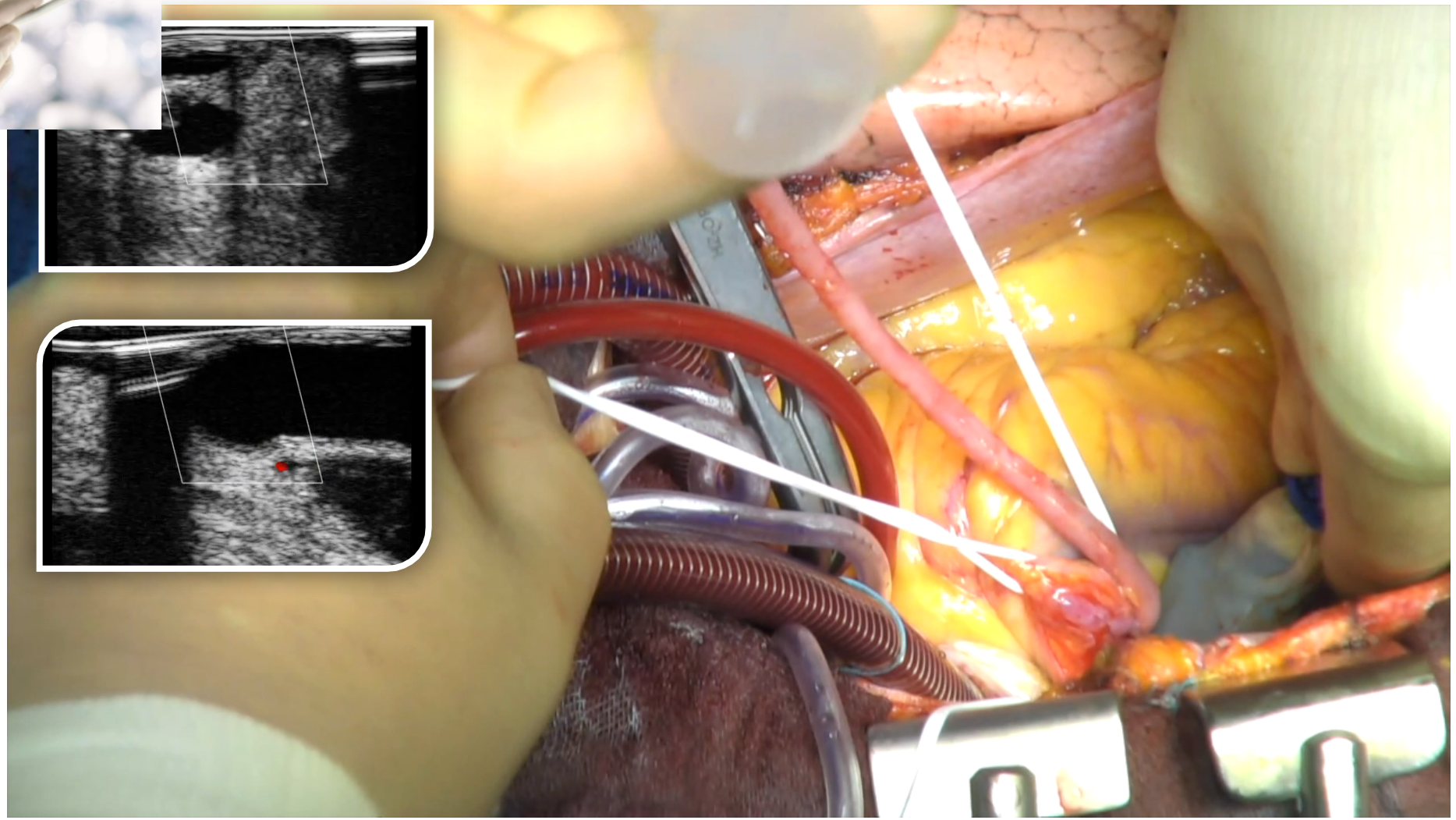
Target coronary scanning: CX



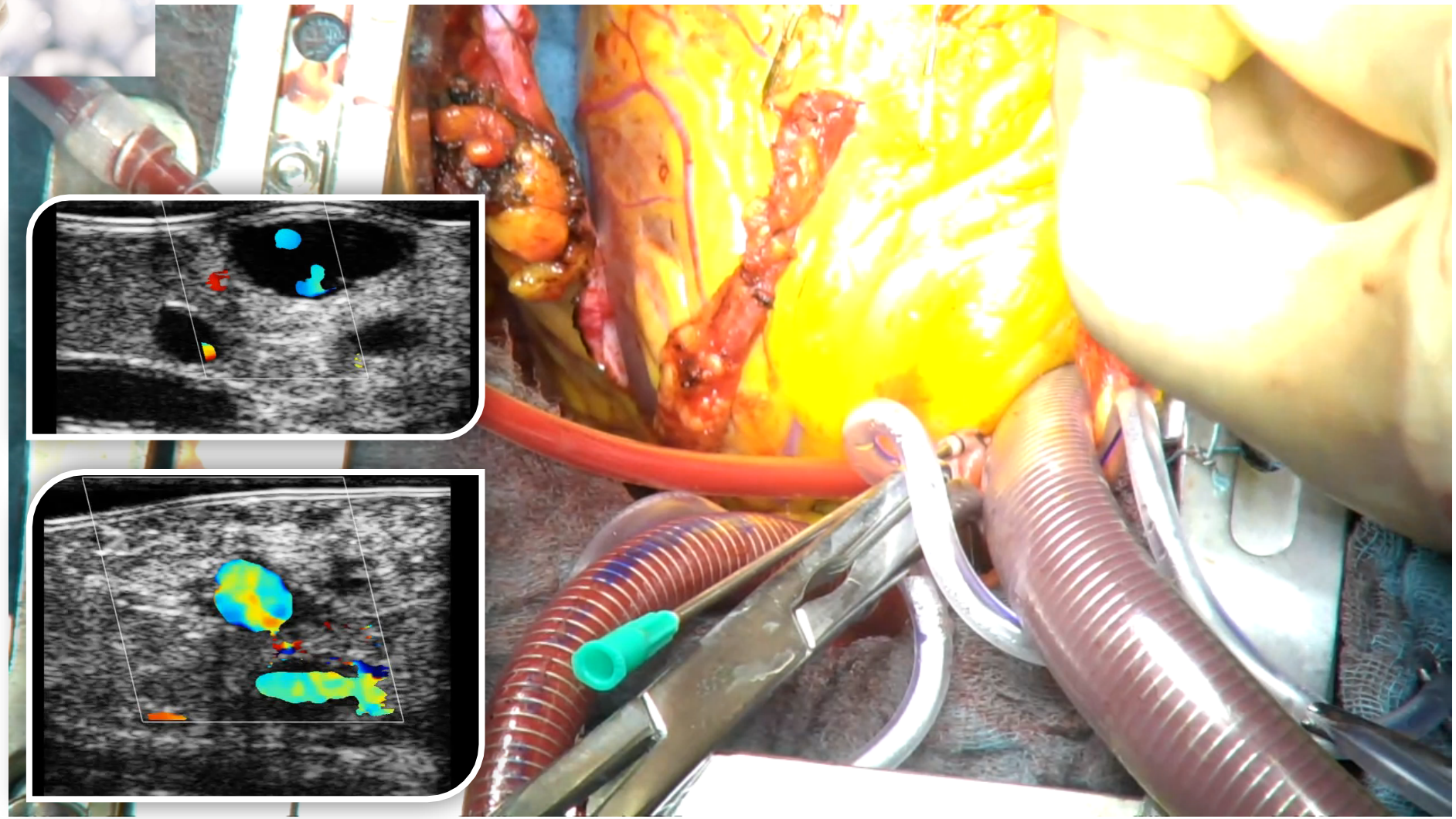
Scanning of SVG-CX xclamp cardioplegia



Anastomosis SVG-RCA – with cardioplegia



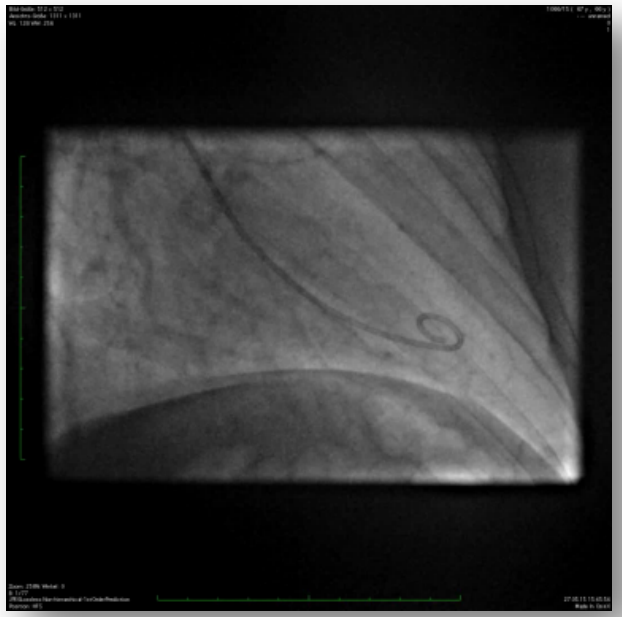
Scanning of LIMA-LAD on pump



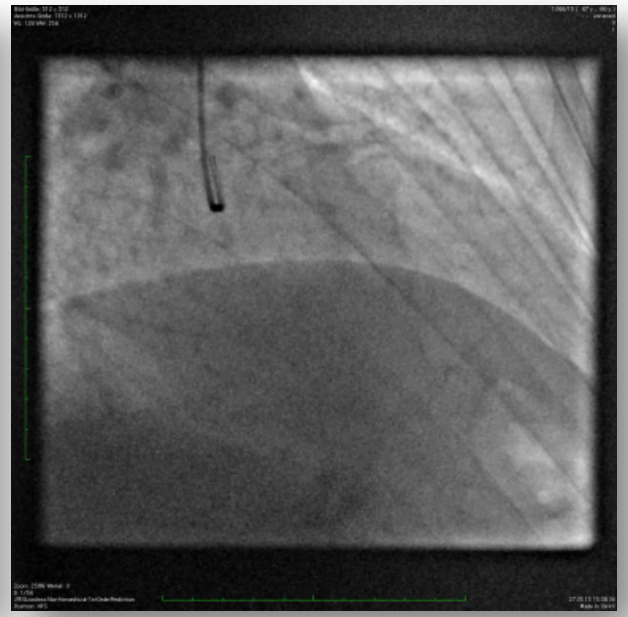
Case: W. K.

67years, DM, hypercholesterolemia, LVEF 65%, multiple allergies, systemic hypertension

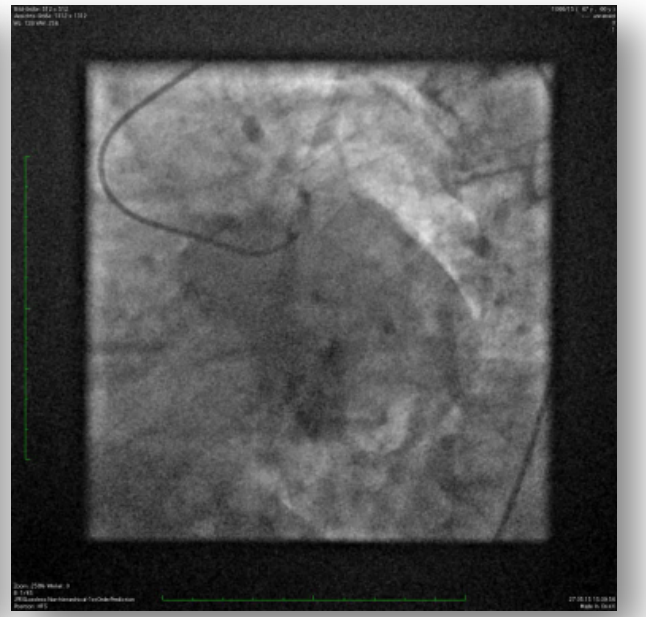
good LVEF



LAD occlusion



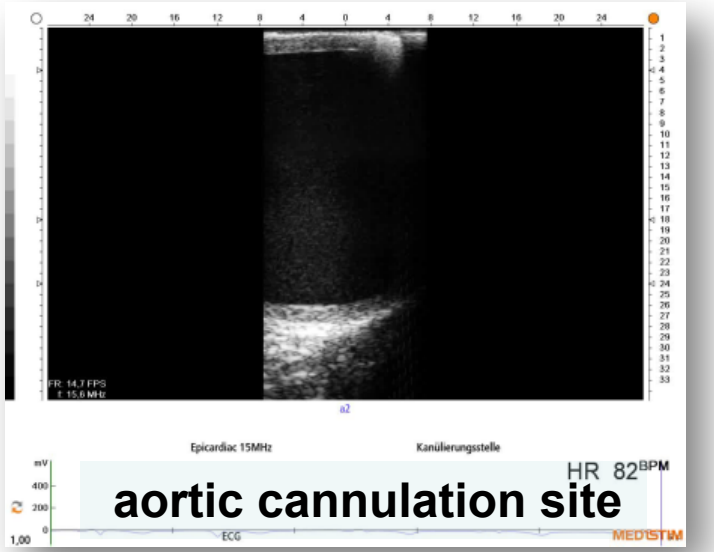
Cx stenosis



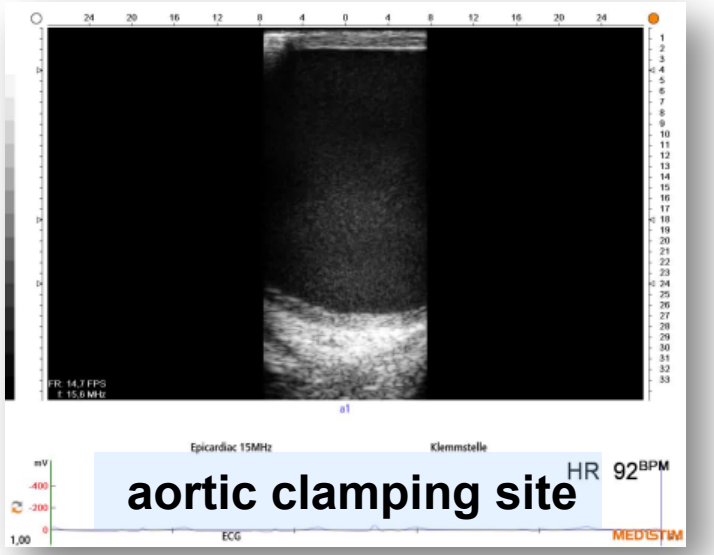
Case: W. K.

Epiaortic scanning & graft evaluation

LIMA evaluation



aortic cannulation site

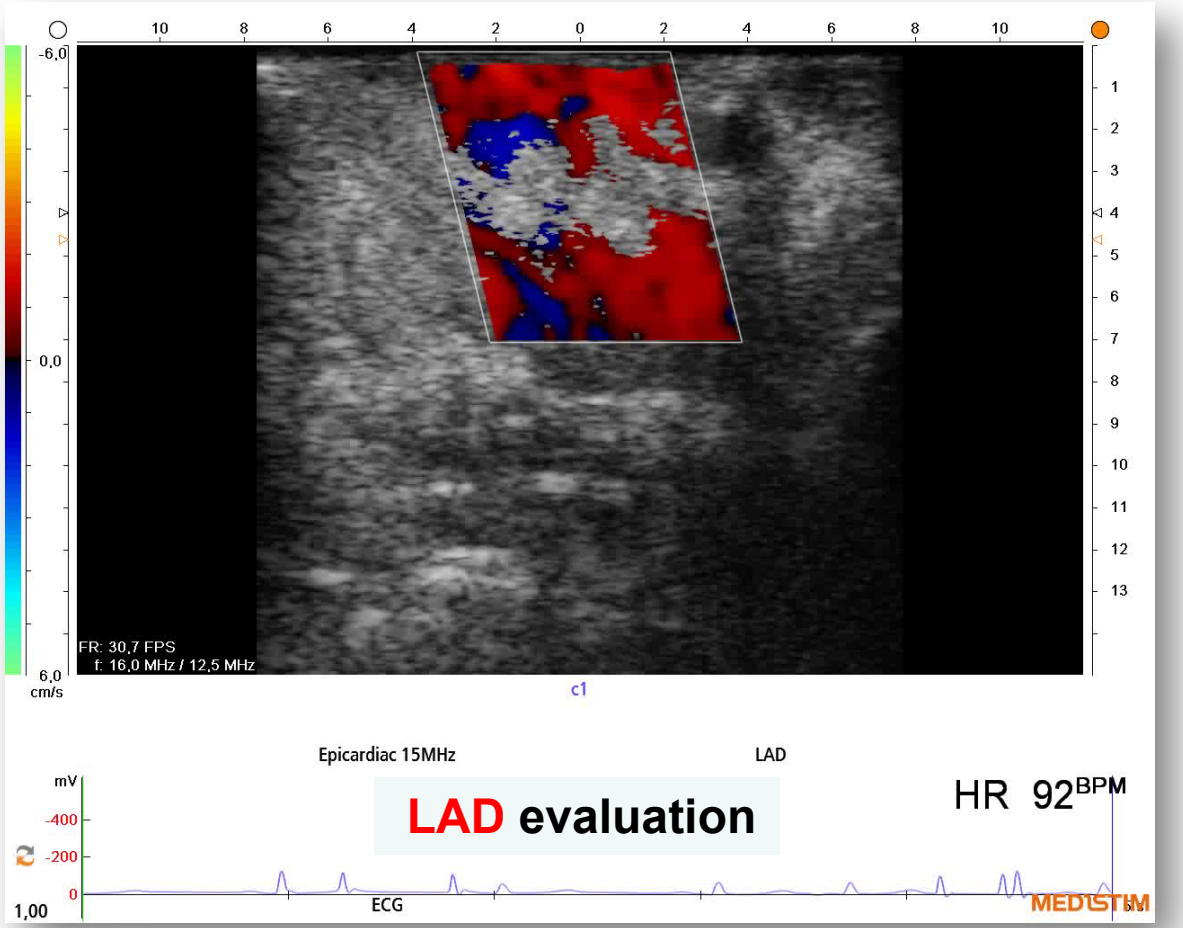


aortic clamping site

Case: W. K.

Epicardiac scanning

- Vessel identification
- Calcium identification
- Flow identification
- Potential opening?
- Diameter?



LAD evaluation

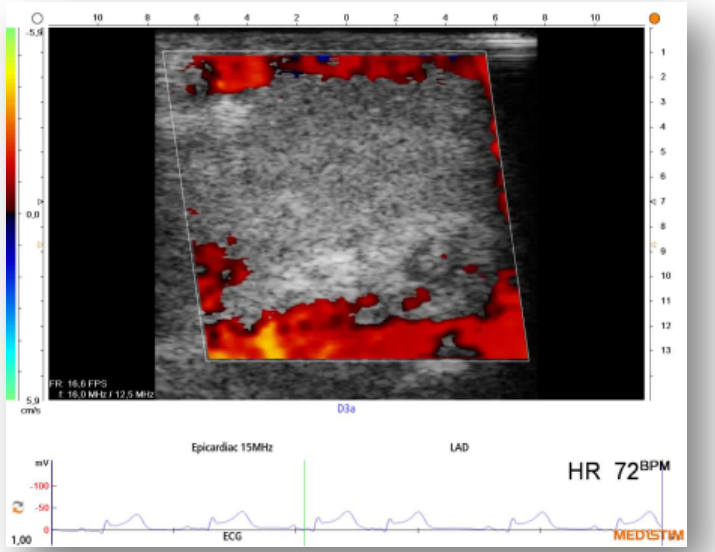
Case: W. K.

3xCABG:

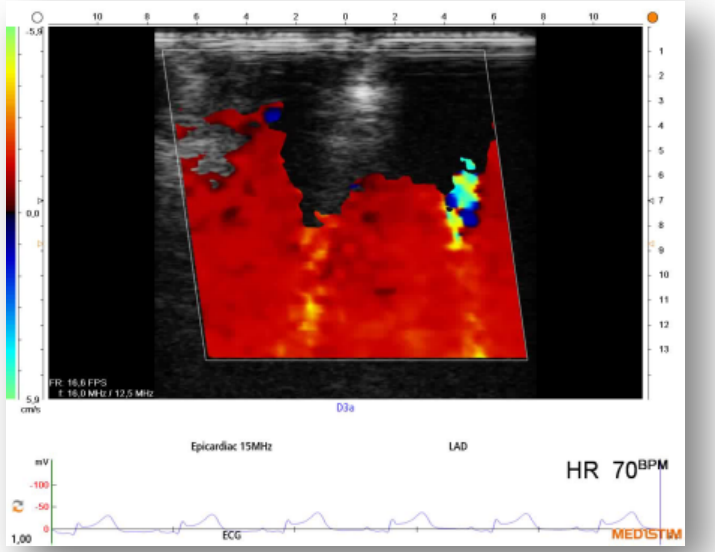
LIMA → LAD

V → OM1 → OM2

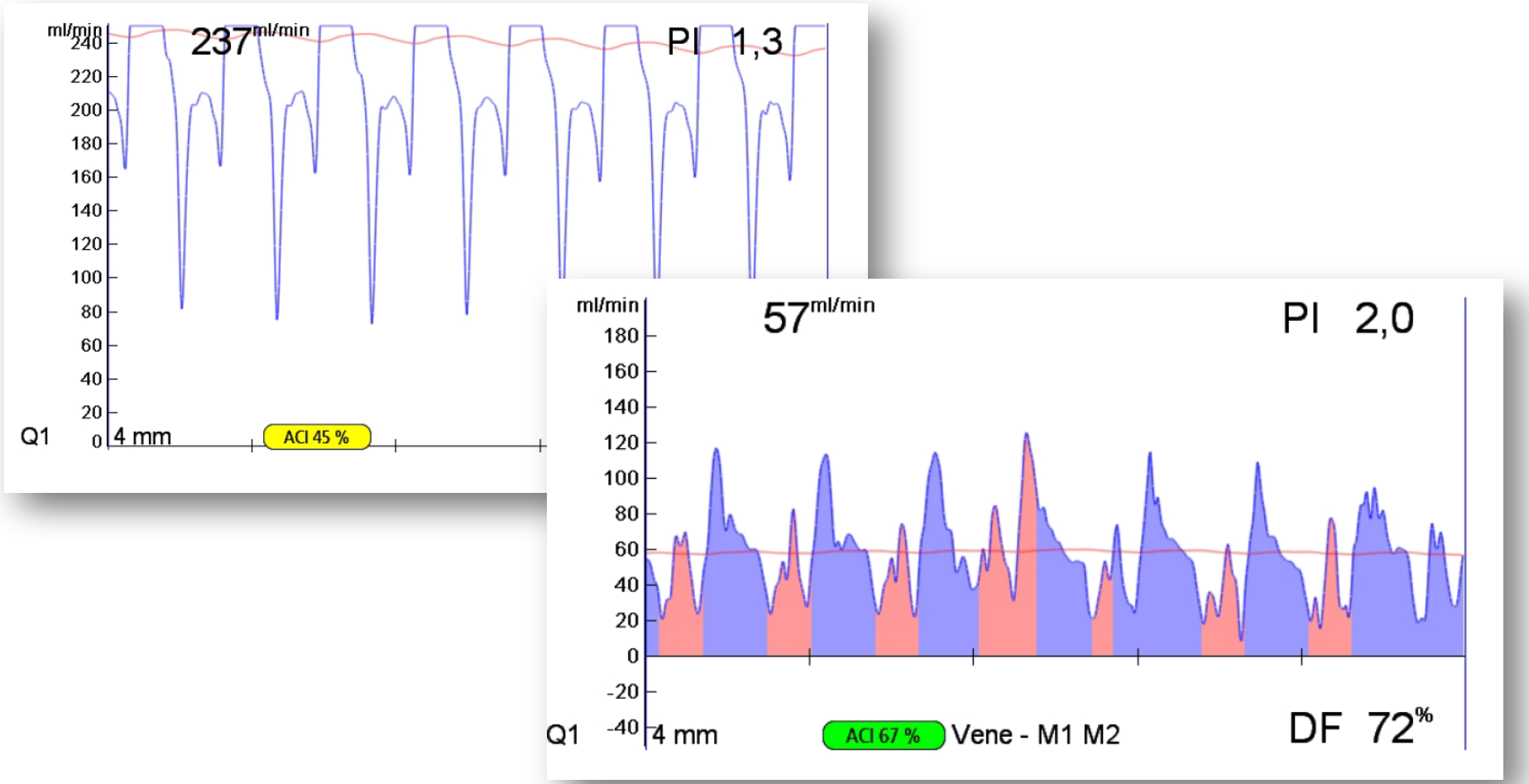
LAD anastomosis



distal LAD



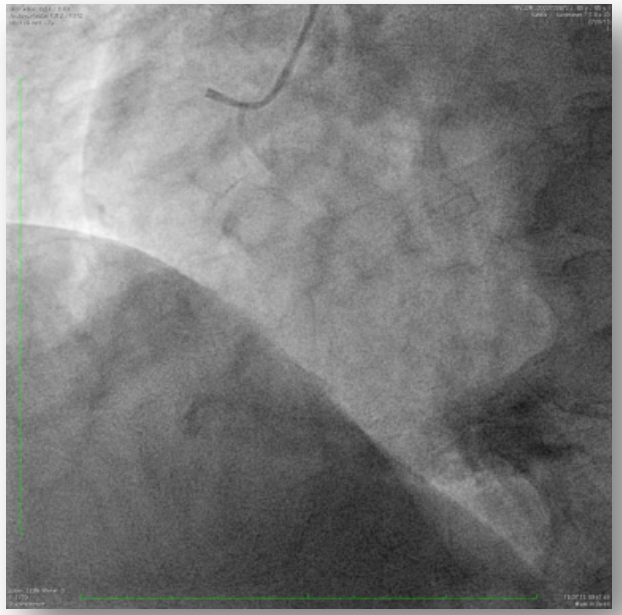
Case: W. K.


ml/min
237 ml/min
PI 1,3
240
220
200
180
160
140
120
100
80
60
40
20
0
Q1
4 mm
ACI 45 %
ml/min
57 ml/min
PI 2,0
180
160
140
120
100
80
60
40
20
0
-20
-40
Q1
4 mm
ACI 67 %
Vene - M1 M2
DF 72%

Case: J. N.

65years, DM, systemic hypertension, hypercholesterolemia, smoking

RCA



LAD PCI, 70-80% stenosis post stent

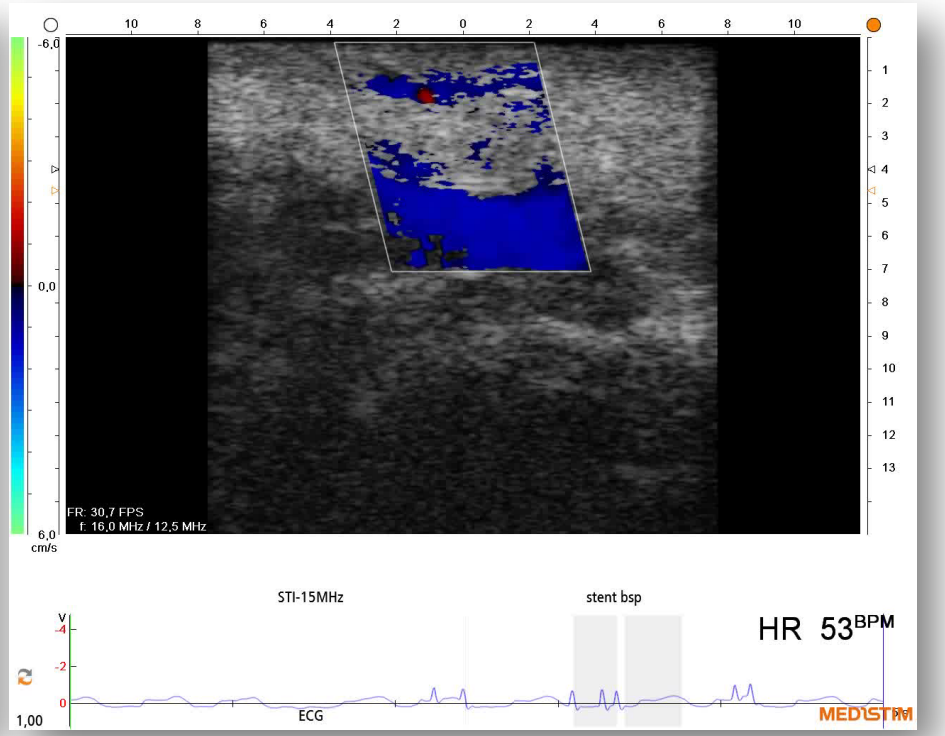
LAD *post 2xDES*

Case: J. N.

Epicardiac scanning

LAD

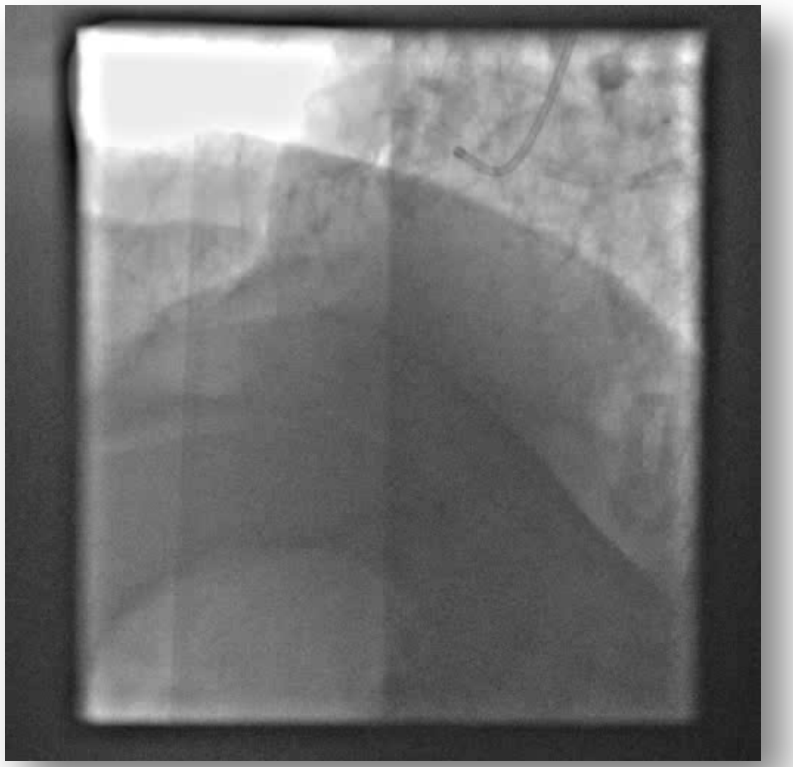
stent



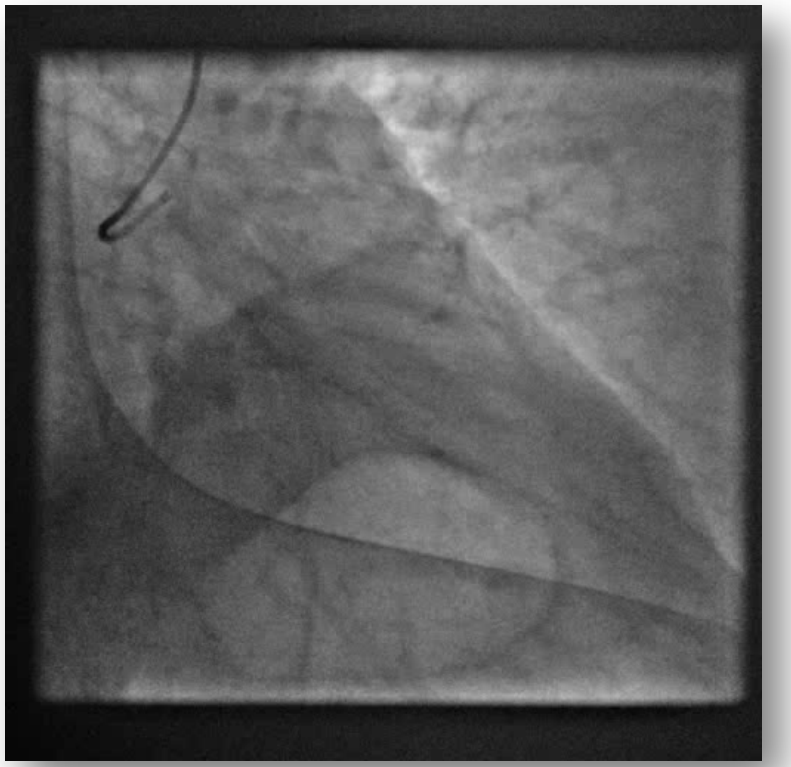
Case: M. I.

77years, DM, systemic hypertension, smoking, COPD, post carcinoma

RCA, CTO



Left system



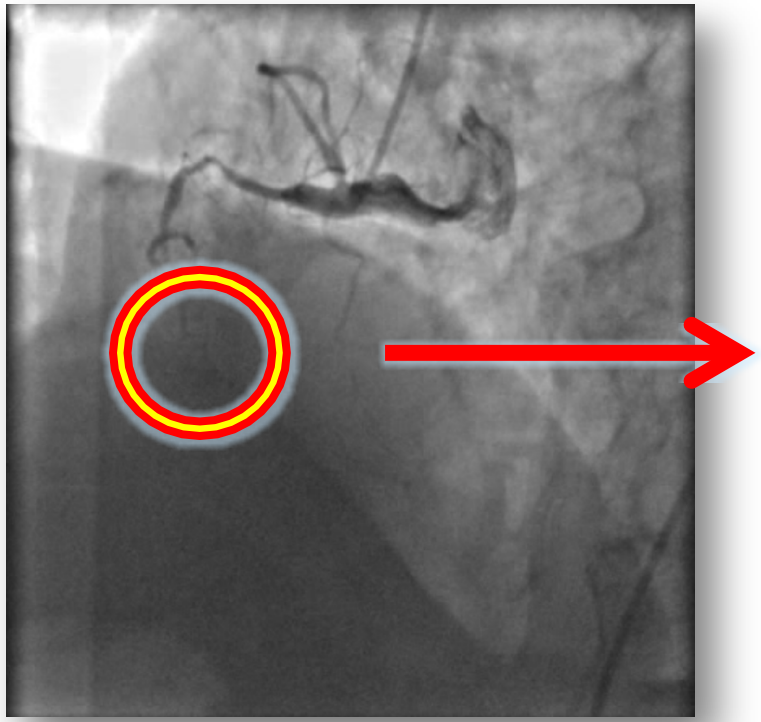
Planned: V → RPD, V → OM1, LIMA-LAD on **2nd Oct 2015**

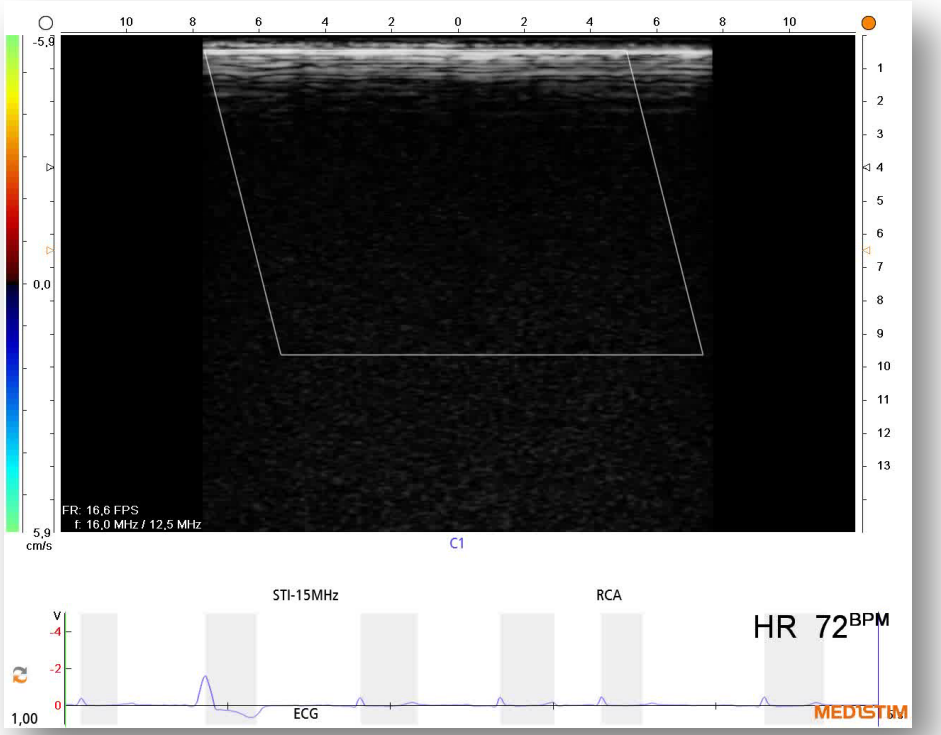
Case: M. I.

Epicardiac scanning

prox. RCA, CTO

...intended RPD → calcification

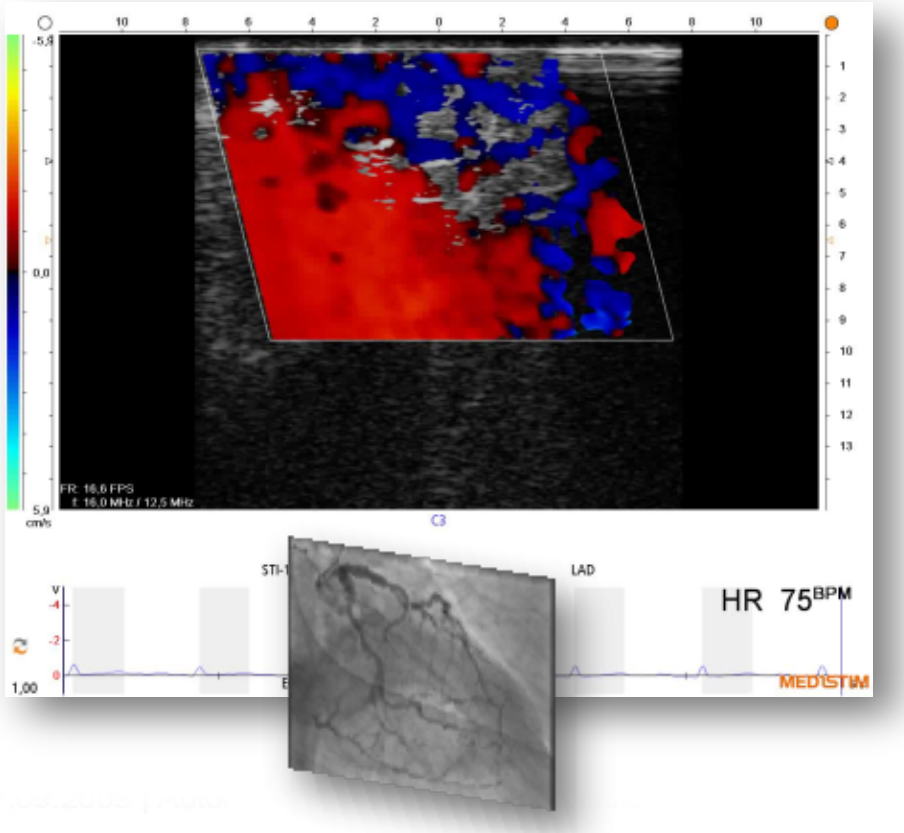




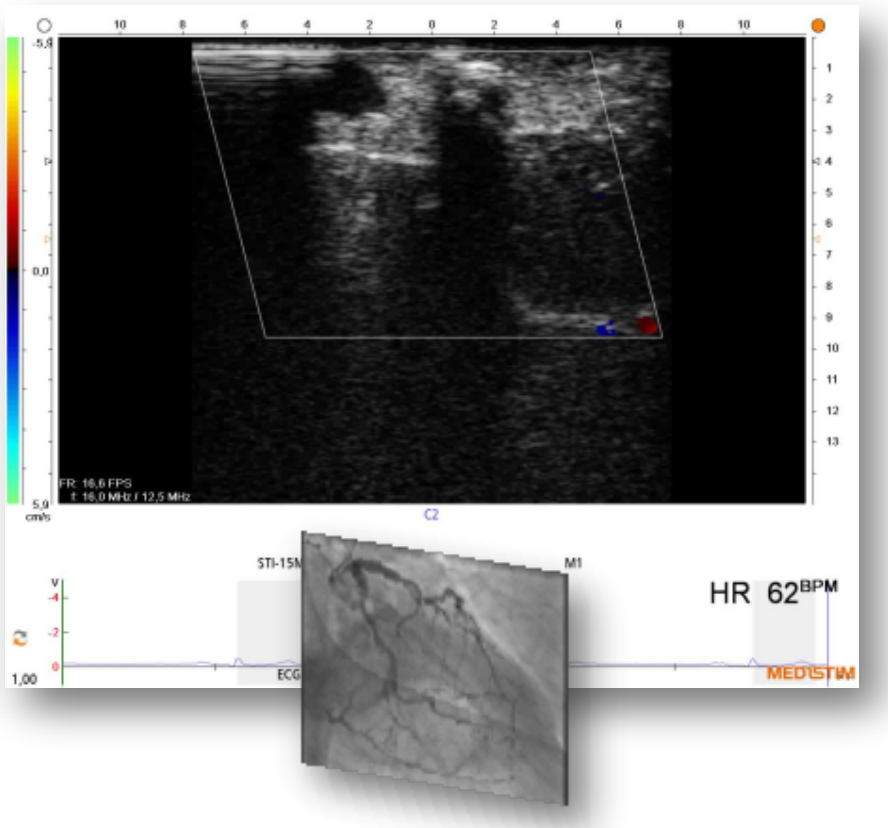
Case: M. I.

Epicardiac scanning

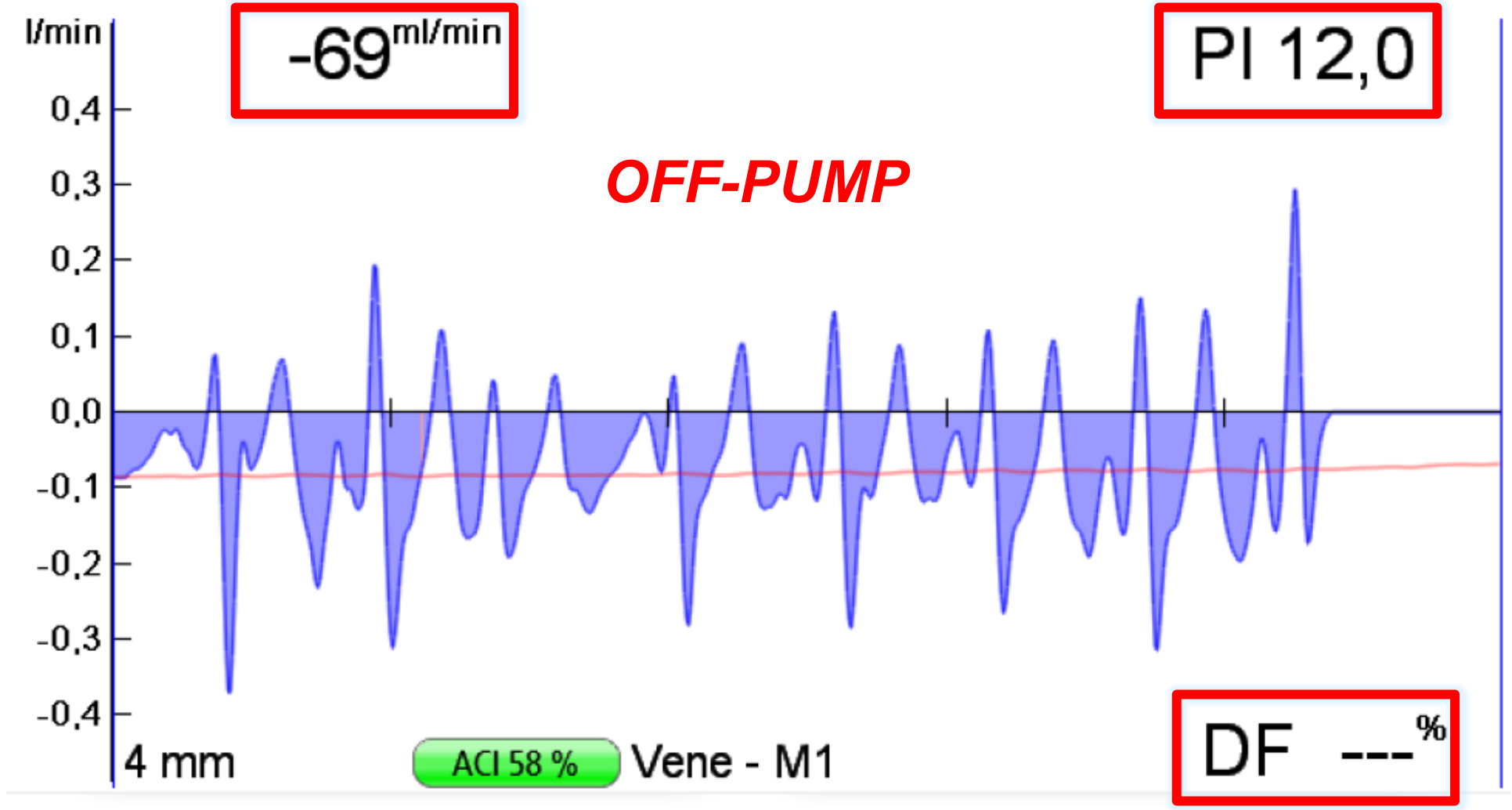
LAD
less calcification



OM1
total calcification, no lumen

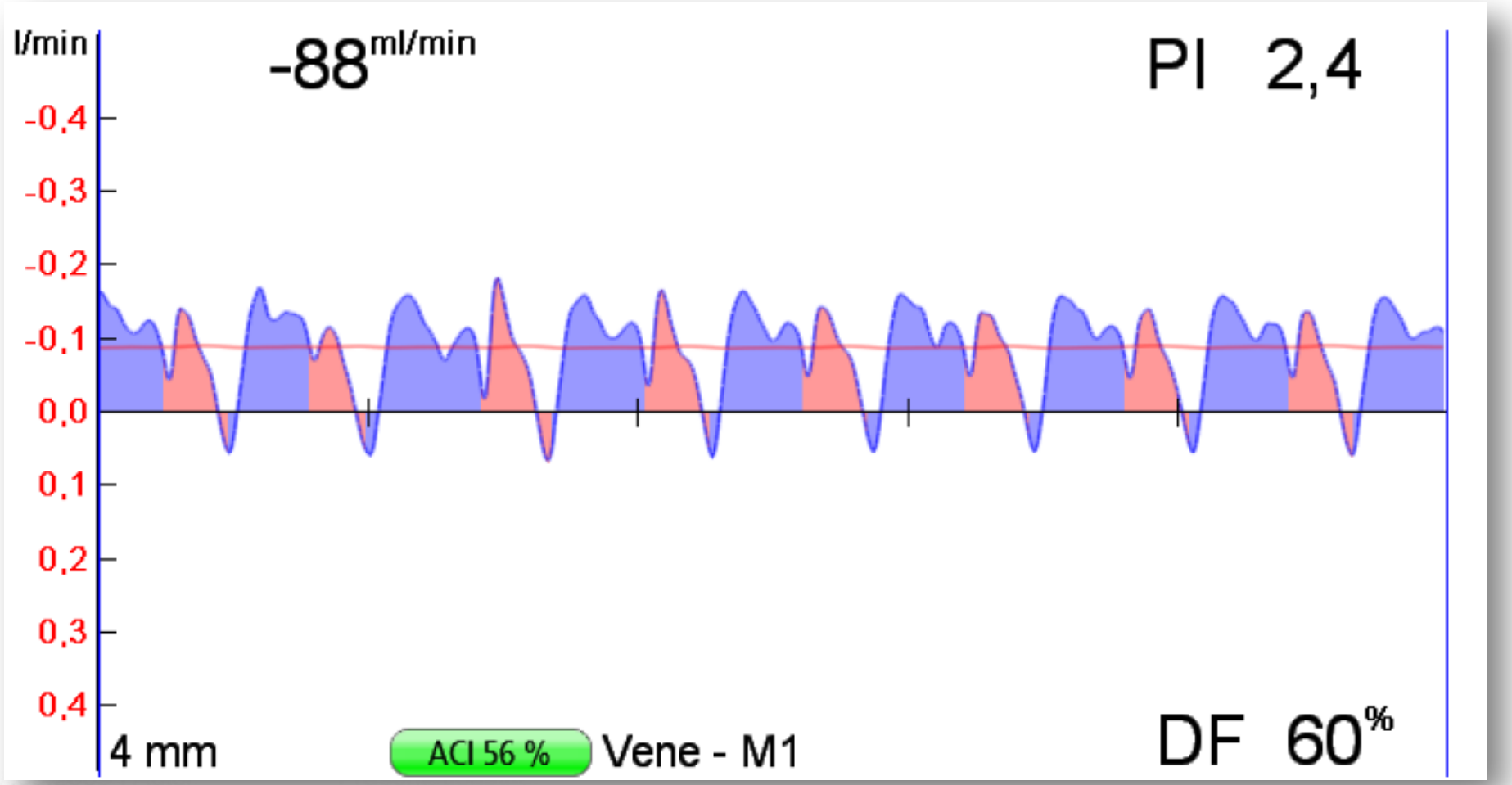


Case: M. I.


l/min
0,4
0,3
0,2
0,1
0,0
-0,1
-0,2
-0,3
-0,4
-69 ml/min
PI 12,0
OFF-PUMP
4 mm
ACI 58 %
Vene - M1
DF ---%

Case: M. I.

Measurement OFF-PUMP after interponation



Case: ruptured plaque

Patient characteristics:

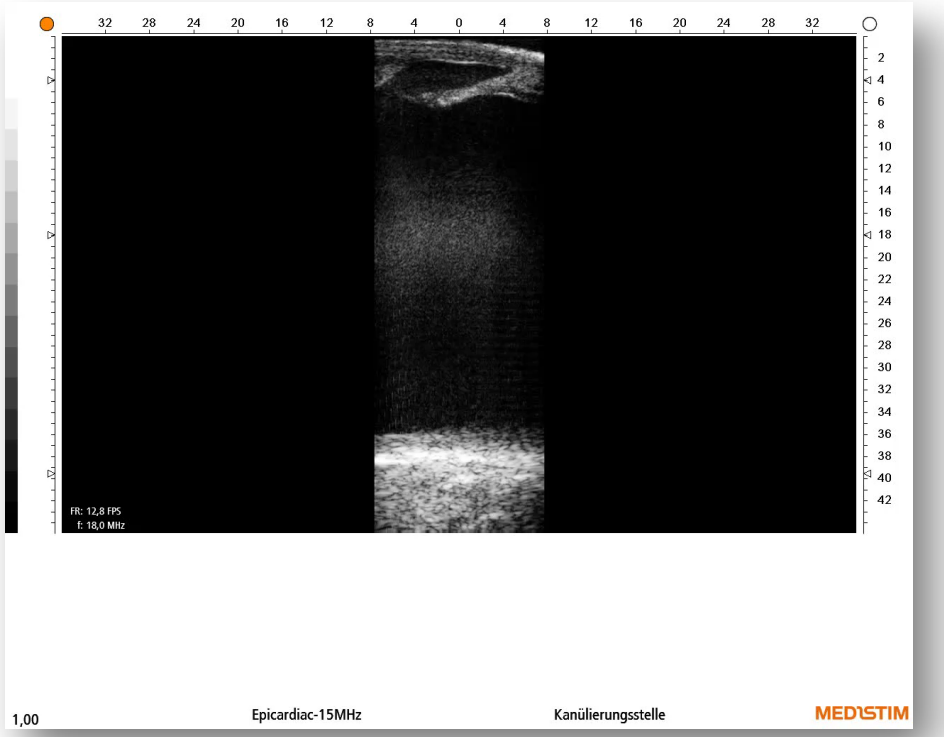
- male, 69 years
- MI III°
- 3 vessel CAD
- paroxysmal aFIB

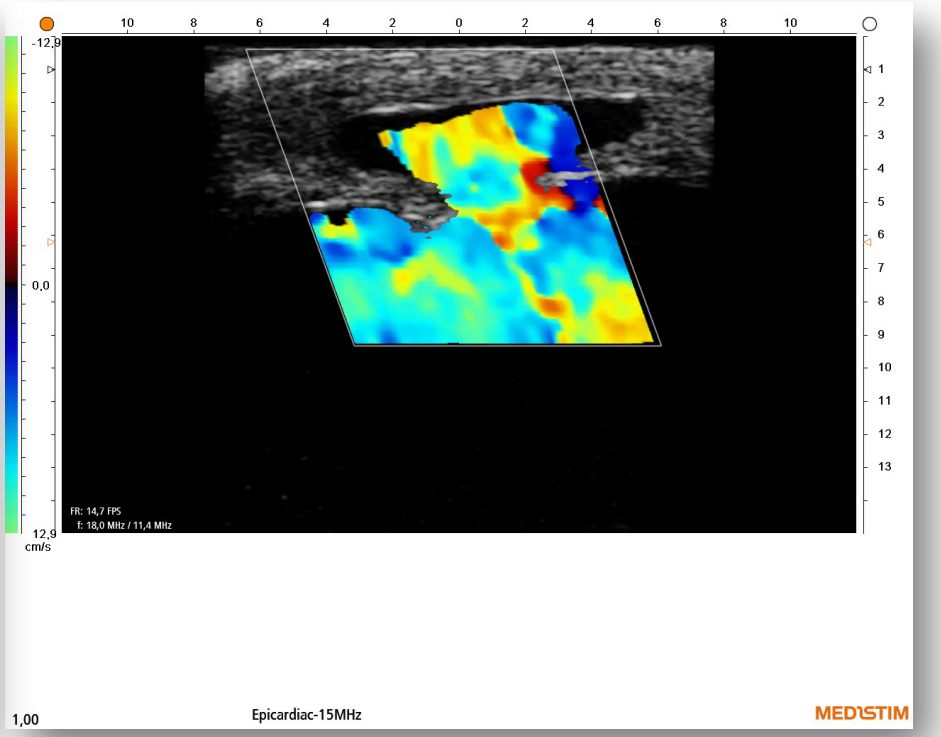
planned procedures:

- CABG
- MVR

Case: ruptured plaque

Intraoperative finding in distal ascending aorta





Case: ruptured plaque

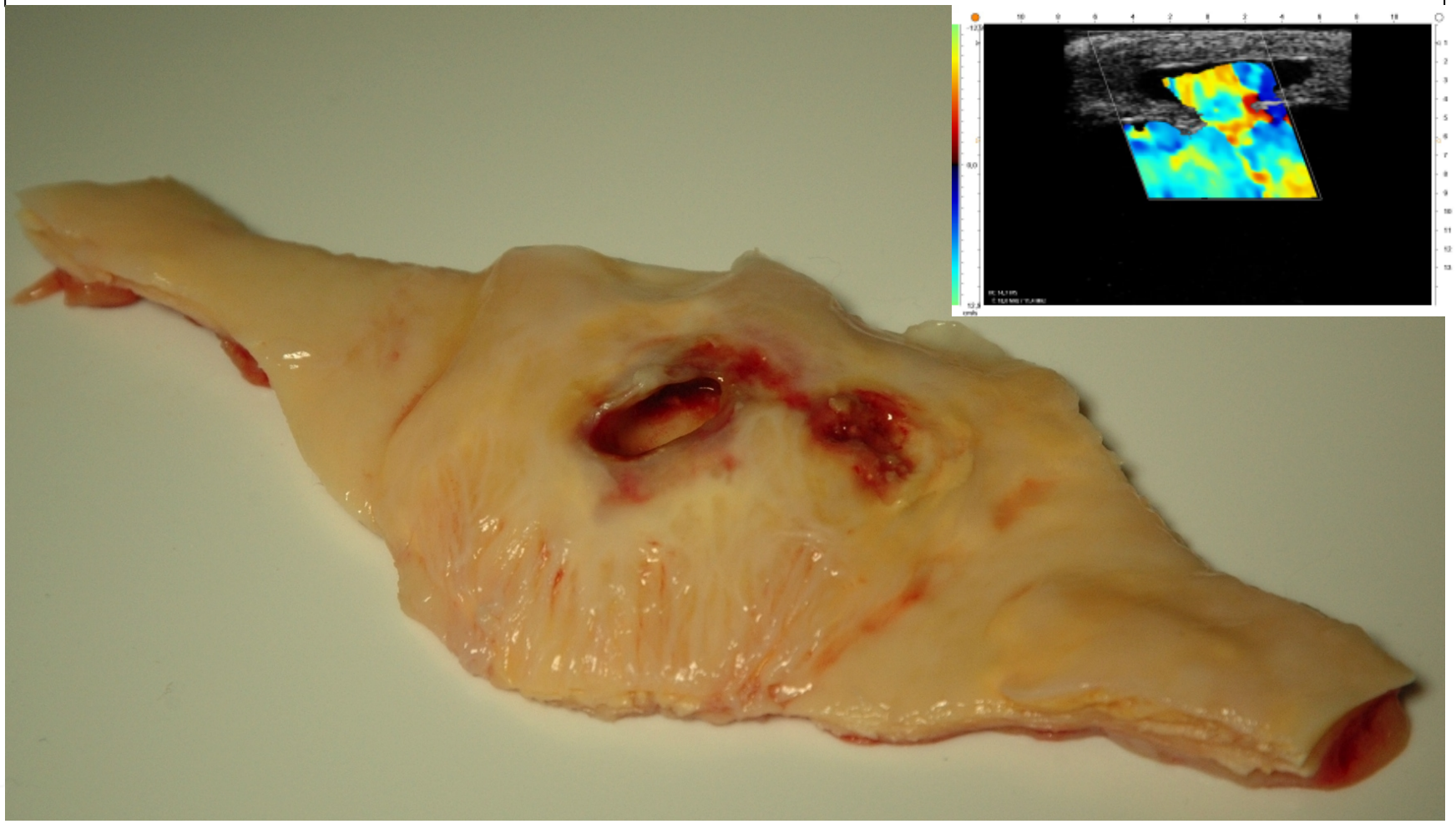
Change in operative strategy

New strategy:

- **Cannulation of aortic arch and cooling to 26°C**
- **proximal cross clamp**
- **Mitral valve replacement**
- **at 26°C HCA (15 min)**
- **Ascending replacement with open distal anastomosis**

Case: ruptured plaque

Macroscopic findings in congruence to EAS



discussion & conclusion

- TTFM offers quick, easy, noninvasive and reproducible, cost saving intraoperative evaluation of the graft function
- Results have to be related to graft type, vessel size, degree of stenosis
- TTFM and HFUS/ epicardiac scanning enable functional and morphological evaluation / higher diagnostic accuracy
- Epicardiac scanning allows for decision making
- EAS enables direct evaluation of the aortic wall intraoperatively
- EAS allows for decision making in order to avoid embolism
- Safety / quality / education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